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The Application of the Concept of Supply Chain Management in the Construction Industry

Paweł B. Michalski
Wroclaw University of Economics, Faculty of Management, Informatics and Finance, Poland

The innovation and practicality of SCM solutions has been used in the construction industry relatively recently. Companies and construction companies have recognized the concept of supply chain management as a way to reduce costs, improve production quality, shorten project execution time and increase scheduling flexibility.
Construction Supply Chain (CSC) refers to the whole project. The links in this chain are the suppliers and recipients of raw materials, materials, machines and equipment, people (workers), money and technical documentation, as well as many different information and intangible assets that are necessary for the execution of works and structures.
Well planned and developed logistics concepts and logistics management solutions provide the opportunity for efficient project execution and cost reduction related to logistics as well as total project cost. An important element in increasing the efficiency of the project is the proper coordination of the logistics processes of all its stakeholders at every stage of the investment cycle.
High risk of construction investment, mortgage crisis and high customer demand - this is the real estate market nowadays. Looking for solutions, on the one hand minimizing the costs of contractors, on the other hand it is important to maintain the high quality of the product. Can CSCM be the answer to the current state of affairs?

Keywords: construction supply chain, logistics, materials flow

1. INTRODUCTION

Supply chain management is based on many theories and scientific fieldswhich provides it with a multidisciplinary character. There is no universal definition of supply chain and supply chain management, which results in continuous development and adaptation of assumptions in subsequent, new areas.

Innovation and practicality of solutions used in classical supply chains has been used in the construction industry relatively recently. Companies and construction companies have recognized the concept of supply chain management as a method allowing reducing costs, increasing production quality, shortening the time of project completion and increasing the flexibility of scheduling.

The construction supply chains cover the whole enterprise (project). Links in this chain are suppliers and recipients of raw materials, materials, machinery and equipment, people (employees), money and technical documentation, as well as a variety of information and intangible assets that are necessary for the execution of projects and construction works[1].

The author's goal is to present the applications of the supply chain, in the context of the functioning of the construction industry.

In his deliberations, the author considers standard features of the supply chain, which are also the basis for planning and implementing construction projects. This specific industry, often resistant to the latest logistics solutions, is strongly supported by concepts known from the supply chain literature.

[1] A. Sobotka, P. Jaśkowski, *Zarządzanie łańcuchem dostaw w realizacji przedsięwzięć budowlanych*, GMiL no. 11/2009.

2. THE SPECIFICITY OF THE CONSTRUCTION INDUSTRY AGAINST THE BACKGROUND OF THE CLASSIC SUPPLY CHAIN

The construction industry has features that distinguish it from other industries in a specific way. These are: the physical nature of the product, the structure of the industry and the organization of the construction and building processes. A construction product is usually large and expensive, and because it is permanently located in a specific geographical area, it is unsuitable for transport.

Buildings and other constructions are usually made to meet the requirements of a given customer. Three separate groups of people are involved in the construction process: the client / investor, the designer and the contractor. The customer is the initiator of the construction process. The designer creates a project and plans the main works. The contractor performs construction and construction works (including in the residential, commercial and engineering sectors). The work system in the construction industry is based on projects.

Each project employs from several to several hundred subcontractors (companies) who have specific objectives. Organization of the management of the construction process, in order to function efficiently, requires from the project manager a comprehensive control of costs as well as time and quality of undertaken activities. Project management is temporary but exposed to constant pressure from time and cost constraints, enormous competition during tenders and investor pressure to select the cheapest bidders / subcontractors[2].

Organizations from the construction industry employ from several dozen to several thousand employees. Large construction companies are divided into divisions, within which individual projects are implemented, which are led by managers. A project manager is responsible for the organization of the entire construction process, including the delivery of materials and equipment, and after completion of construction, for the procedure of handing over the facility to the user.

In the last twenty years, most companies within all industries have begun to see supply chain management as a new way of doing business. They adapted the supply chain concept to their needs and defined it in many different ways. Implementation of this new approach was the consequence of various changes, especially in production environments, such as the development of information technology (Internet), globalization and sophisticated customer needs, which require more and more variety of products, lower costs and better quality as well as faster response to changing tastes.

SUPPLY CHAIN

According to Sobotka, the term "supply chain" refers to processes (sometimes sequential and sometimes parallel) implemented by organizations, as well as the flows among them, supported by infrastructure (people, devices, buildings, software, etc.). Flows determine the current or future demand for resources (in the form of raw materials and products) and supplies satisfying it i.e. products, information, money and employees[3]. The concept of supply chain is also defined as a network of organizations in supply channels that generate value for customers and contribute to achieving and maintaining a competitive advantage[4]. Kiefer and Novack define the supply chain as an integrated set of organizations that manage information, product and cash flows to maximize consumption satisfaction with a minimum total cost[5]. Witkowski, on the other hand, argues that "the essence of modern supply chain management is the decision-making process related to synchronizing physical, informational and financial streams of demand and supply flowing between its participants in order to achieve their competitive advantage and create added value for the benefit of all of its links, customers and other stakeholders"[6].

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2 Holmse, N., Lingard, H., Yesilyurt, Z. and De Munk, F., *An Exploratory Study of Meanings of Risk Control for Long Term and Acute Effect Occupational Health and Safety Risks in Small Business Construction Firms,* Journal of Safety Research, no. 34/1999.

3 Sobotka A., Wałach D., *Koncepcja zastosowania metody zarządzania łańcuchem dostaw w procesie inwestycyjnym w budownictwie*, Budownictwo i Inżynieria Środowiska, no. 2/2011.

4 Cox, A., *Power, Value and Supply Chain Management. Supply Chain Management*, International Journal, no. 4/1999.

5 Kiefer, A.W. , Novak, R.A., *An Empirical Analysis or Warehouse Measurement Systems in the Context of Supply Chain Implementation,* Transportation Journal, no. 38/1998.

6 Witkowski J., *Zarządzanie łańcuchem dostaw. Koncepcje, procedury, doświadczenia*, PWE, Warszawa 2003, p. 29

While the approach to supply chain management in production has developed over the years and has become an integral part of this industry, in construction industry it is a relatively new area of interest. Stakeholders in the construction industry, i.e. customers, contractors, suppliers and subcontractors, are still looking for answers on how supply chain management will increase competitive advantage.

Supply chains in the construction industry can be characterized by high complexity. In large-scale projects, the number of suppliers and subcontractors involved is huge (Fig. 1). In a construction project, a delay in the supply of materials may cause a domino effect in the form of a delayed work, which in turn may lead to a delay in the completion of the entire investment. A similar effect may be caused by delays on the part of subcontractors. At the corporate level, the number of parties involved in the supply chain can

PARTNERSHIP IN CONSTRUCTION PROJECTS

According to Titus and Bröchner, the supply chain in the construction industry deals with the management of materials, but also with the relationship between contractors, suppliers and distributors[7]. The simplest definition according to O'Brien and Fischer defines supply chain management as a system in which suppliers, contractors and clients cooperate with the main contractor in the area of production of raw materials, deliveries, assembly, information and material flow, organization of temporary work, equipment and manpower, and other resources necessary for construction projects[8]. Welling and Kamann presented a similar approach to cooperation in the supply chain, while differentiating between two types of cooperation - at the company level or at

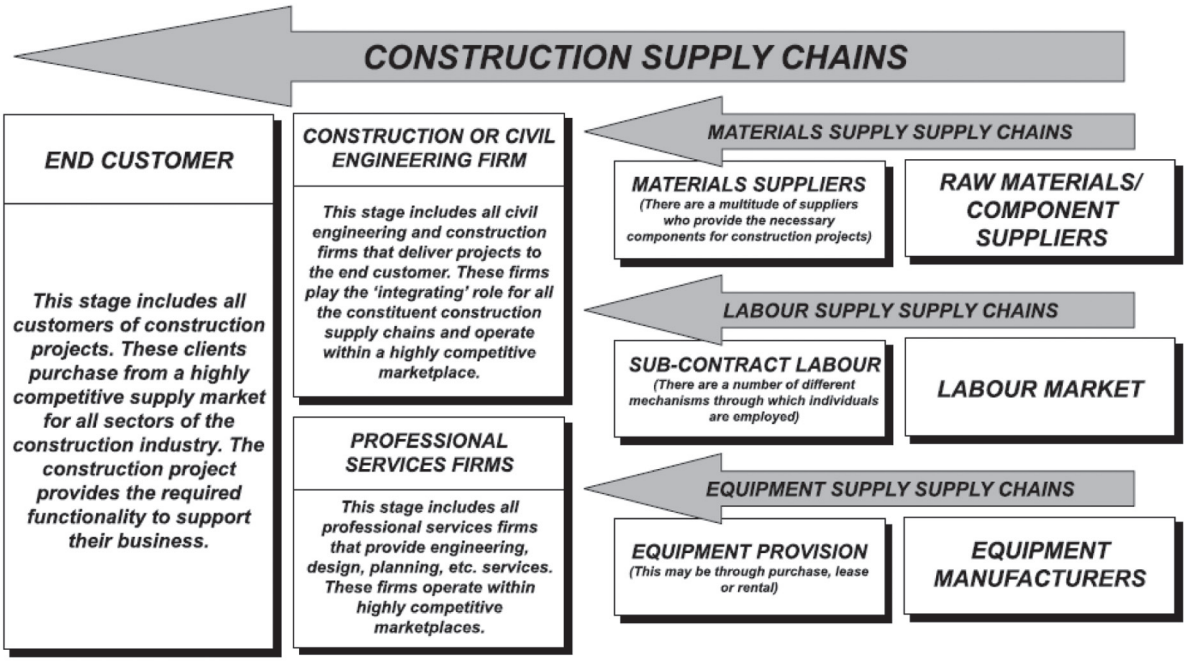

Fig. 1. Countless supply chains in construction industry

Source: Cox, A., Ireland, P., 2002. Managing construction supply chains: the common sense approach. *Engineering, Construction and Architectural Management*, 9, 409-418

grow to thousands on an annual basis. The general contractor, who is the main project coordinator, has a strategic position to manage all project participants and resources in the supply chains. Implementation of the project on time, within the set budget and with a certain quality level, means that it must adequately manage delays or disruptions in the flow of the supply chain during construction.

7 Titus, S., Bröchner, J., *Managing Information Flow in Construction Supply Chains*, Construction Innovation, no. 5/2005.

8 O'Brien, W.J., Fischer, M.A., *Construction supply-chain management: a research framework, in Proceedings of Civil Comp 93*, Information Technology for Civil and Structural Engineers, Edinburgh 1993, pp. 61–64.

the project level[9]. At the enterprise level, partners in the supply chain can have stable and long-term working arrangements among a limited number of companies. Such cooperation was defined as permanent networks[10]. Relationships at the project level are more temporary because they are usually set for the duration of the project - what Dubois and Gadde referred to as "loose couplings"[11]. Koskela and Vrijhoef argue that temporary partnership is an inhibitor of innovation[12]. Another type of partnership has been defined by Lovea et al., Refers to strategic or project alliances. In this case, the project partnership is the relationship established for a single project that "focuses on short-term benefits" while the strategic partnership is long-term and involves many projects - "strives for long-term profit"[13].

THE ROLE OF SUBCONTRACTORS IN A CONSTRUCTION PROJECT

Subcontractors play an important role in achieving a reliable workflow in the project, because they help the general contractor in the implementation of tasks by carrying out specialist work. Often, as much as 80% of the construction project is subcontracted, therefore it happens that subcontractors contribute to the development of 80% of the turnover of the general contractor. Earlier involvement of subcontractors in the project allows them to better understand the venture and helps in general relations with the general contractor, which pays off in trust and teamwork between the parties. Good relations between the main contractors and subcontractors are a strategic asset for both of the stakeholders. These factors point to the extremely important position and contribution of subcontractors to the final success of the project.

3. CHARACTERISTICS OF THE SUPPLY CHAIN IN CONSTRUCTION INDUSTRY

A typical supply chain in construction (CSC - Construction Supply Chain) includes information flow and material flow (Fig. 2). Cox and Ireland are extending this concept by writing about material supply chains, labour supply chains and equipment supply chains as additional CSC elements[14]. This division can be further developed, assuming that supply chains in construction occur in three categories: the primary supply chain, the support supply chain and the human resource supply chain. The main supply chain provides materials that are used in the final construction product, for example: raw materials, components, subassemblies and mechanical and electrical equipment. The support chain provides equipment, expertise and materials to facilitate construction, for example: frame structures and supports, excavation supports, scaffolding, temporary work related to the operation of equipment, protection of the construction site. The human resources supply chain includes the provision of manpower and supervisory staff - as a contribution to the construction process[15].

INFORMATION FLOW

The efficient flow of information, which is transferred between project stakeholders along the supply chains, is the basis for the effective implementation of the project. The information is materialized in the form of technical documentation such as drawings, material lists, technical conditions, explanations and solutions proposals.

9 Welling, D., Kamann, D., *Vertical cooperation in the construction industry: Size does matter?*, Journal of Supply Chain Management, no. 37/2001.

10 Dubois, A., Gadde, L – E., *Supply strategy and network effects – purchasing behaviour in the construction industry,* European Journal of Purchasing and Supply Management, no. 6/2000.

11 Dubois, A., Gadde, L – E., *The construction industry as a loosely coupled system: implications for productivity and innovation,* Construction Management and Economics, no. 7/2002.

12 Koskela, L., Vrijhoef, R., *Is the current theory of construction a hindrance to innovation?*, Building Research & Information, no. 3/2001.

13 Love, P.E.D., Irani, Z., Cheng, E., Li, H., *A Model for Supporting Inter-Organisational Relations in the Supply Chain*, Engineering Construction and Architectural Management, no. 9/2002.

14 Cox, A., Ireland, P., *Managing construction supply chains: the common sense approach,* Engineering, Construction and Architectural Management, no. 9/2002.

15 Muya, M., Price, A.D.F., Thorpe, A., *Contractors' supplier management, in Proceedings of a Joint CIB W55/65 Triennial Symposium,* Customer Satisfaction: A Focus for Research and Practice in Construction, Cape Town 1999, pp. 632–640.

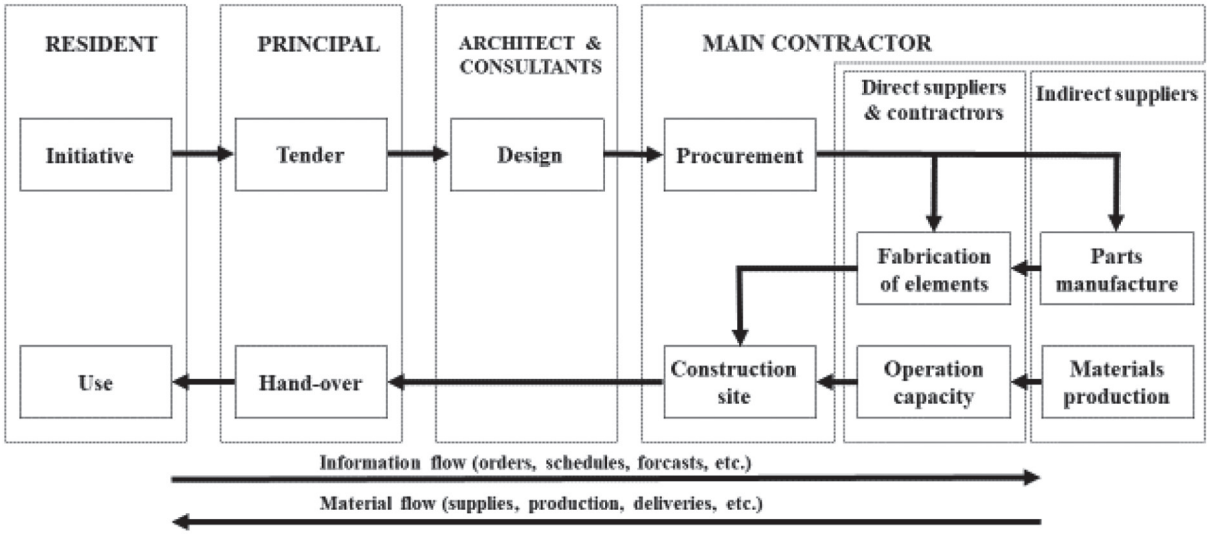

Fig. 2. Characteristics of the supply chain in construction
Source: Koskela, L., Vrijhoef, R., 1999. *Roles of Supply Chain Management in Construction*. University of California, Berkeley, 138

The project's success depends on a well-organized, timely, flow of information throughout the supply chain. One of the main reasons for delays in the implementation of projects is the slowing down of the decision-making process in project teams involved in the undertaking, caused by a delay in the flow of information. Sharing information between members of the supply chain is seen as the key to effective management of this chain, although this is not easy due to the complexity of projects and a large number of participants in the supply chain in the construction industry.

MATERIAL FLOW

After receiving the order from the contractor, the suppliers start to deliver the materials to the place of the project within the agreed time. Materials can be delivered once or in batches according to an agreed schedule. Depending on the type of material, the delivery process can be divided into three types, that is: supply chains of non-standard materials (manufactured for a given project), standard materials and small purchases (current needs)[16]. The reasons for delays in the flow of materials are closely related to the quality of materials management. Poor material management has a significant impact on work performance and schedule delays. In some cases, work productivity can be reduced by more than 50%, and construction work can be extended by 50% - 130% more than expected.

LABOUR FLOW

Most construction projects require a lot of effort which means that proper workflow management is critical to the success. After conducting empirical research on three projects, Thomas et al. found that ineffective workflow is responsible for 58% of all ineffective working hours. Delays in the construction work project include the following factors: labour shortage, low skills, poor motivation and low productivity[17].

FLOW RELATED TO WORKSHOPS, EQUIPMENT AND TEMPORARY WORK AT THE CONSTRUCTION SITE

Workshops, equipment and temporary work are other important factors influencing the efficiency and cost-effectiveness of construction projects. Performing temporary work, for which the contractor is responsible, makes it easier for workshops and employees to perform their duties

16 Wegelius-Lehtonen, T., Pahkala, S., *Developing material delivery process in cooperation: an application example of the construction industry*, International Journal of Production Economics, no. 56–57/1998.

17 Thomas, H.R., Horman, M.J., Minchin, R.E., Chen, D., *Improving labour flow reliability for better productivity as lean construction principle*, ASCE Journal of Construction Engineering and Management, no. 3/2003.

efficiently and safely. Some factors that have been identified as causing a delay in this flow include: shortages, poor performance, failures and incorrect selection of equipment[18].

Summarizing, it is worth noting that in terms of structure and function, the supply chain in construction is characterized by the following elements:

- it is a supply chain directing all resources to the construction site where the object is assembled (built) from the materials supplied. Construction works are focused around a single product, as opposed to production systems in which many goods flow through the system and are distributed among many customers;
- with exception to rare cases, it is a temporary supply chain "producing" one-off construction projects through multiple reconfiguration of project organizations. As a result, the construction supply chain is characterized by instability, fragmentation and separation of the architectural design from the physical construction of the facility;
- it is a typical supply chain to order, each construction project creates a new product or prototype. In fact, every built object, even of the same type, is different. The process itself can, however, be very similar, especially for projects of a particular type.

4. THE ROLE OF THE SUPPLY CHAIN IN THE DEVELOPMENT PROCESS OF A CONSTRUCTION PROJECT

The features discussed earlier have a significant impact on the supply chain management in the construction industry. It is worth taking a look at the roles that the supply chain plays in the planning, organization and implementation of a construction project.

How does the supply chain affect works carried out directly at the construction site? Consider the role of the supply chain in the area of activities that have an impact on reducing costs and lead time. In this case, the most important issue is to ensure a reliable flow of materials and manpower to the construction site to avoid disruption in the work schedule. This can be achieved by focusing on the direct relationship between the entity managing the construction work and the direct suppliers. The best and only coordinator is the general contractor of the works.

Another aspect of the role of the supply chain in a construction investment is the reduction of costs. It should focus on the supply chain itself, aiming at reducing costs, especially those related to logistics, lead time and inventory. This also applies to supply chains at suppliers of raw materials and materials. Reducing costs and time can also be achieved by trying to transfer certain activities within the supply chain to the earlier stages. This is justified in construction projects, which, by definition, are characterized by poorer organizational conditions resulting from the technical complexity of the construction process. Such a solution can increase the efficiency of coordination of activities. It is also worth paying attention to integrated management and improvement, both in the supply chain and production (construction works). As a result, production is included in the supply chain. The initiation of these activities can be undertaken by general contractors as well as suppliers or clients.

It should be noted that the roles mentioned above are not mutually exclusive and often appear together.

SUPPLY CHAIN AND THE CONSTRUCTION PROCESS

Supply chains are collections of organizations that work together for the benefit of the end customer. In a business environment where customer relationships and supplier relationships are considered increasingly important, more or less stable constellations of the organization create supply chains. The construction industry lacks deeper relationships between companies involved in the construction process. As mentioned previously, the classic supply chain supplies raw materials, materials, semi-finished products, equipment and human resources to the construction site. This flow intersects and partially permeates with the construction process, which in addition to changes at some stages, for decades, has looked similar (investor, architect, designer, contractor, subcontractor, client).

The author wants to undertake research that would answer the question about the impact of

[18] Chan, D.W.M., Kumaraswamy, M.M., *A comparative study of causes of time overruns in Hong Kong construction projects*, International Journal of Project Management, no. 1/1997.

the degree of integration of these two processes on costs and duration of the construction project. Introduction to the research is the analysis that was carried out during the construction of the shopping-entertainment and office centre - "Złote Tarasy" in Warsaw. Preparations for the start of construction lasted for six years, and the implementation another five years. The general contractor implementing the project made a big step on the path of integration of logistics processes, outsourcing of logistics services, cooperation with clients and architects. This helped to solve many technical and organizational problems and ensured environmental protection, also slightly shortening the construction cycle and, as a result, reducing the economic and social costs of the project. At the same time, it was easy to observe a network of connections that decided of the quality of project management. The weakest side was the flow of information between the construction process and the supply chain, which "provided" the construction. Unfortunately, this applies to both the planning and implementation phases. It seems that developing a model that would integrate these two processes would be the next step on the road to full and efficient cooperation of all parties implementing the construction project.

5. IN THE END

Methodology. Practice in construction not only does not solve problems related to the supply chain, but rather follows the rules that deteriorate its performance. A supply chain can play a very important role in the construction industry. The basis is the general methodology of chain implementation. Supply chain theory and practice in other industries offers general guidelines that can be used to analyse, rebuild, properly coordinate and continuously improve the entire chain in the construction industry. It's worth starting with solving basic problems and ending with getting rid of short-sightedness in planning which plagues construction. This is not possible in a short period of time. It seems that the best solution would be to implement the methodology on a smaller scale, dealing with the smaller problems of the supply chain, with a small number of participants. Repeatability in the methodology in supply chain management determines the process of continuous improvement, whose scope can be extended over time, covering an increasing number of application areas.

Coordination. The flow of materials to the construction site consists of many different flows that are not properly coordinated. The end customer only pays attention to overall efficiency and general efficacy. In order to try to reduce the total costs of a construction project, a holistic approach is necessary. If the flow of materials is not considered as a whole, uncontrolled flows may interfere with and destroy conditions conducive to monitoring other flows. It seems that the efforts made to better coordinate flows by enterprises in the construction industry are insufficient. Some companies try from time to time to seek a reduction in costs in pilot projects, initiated in randomly selected branches of construction corporations. It is definitely not enough.

Partnership. Partnership is of key importance for the implementation of the supply chain in construction. The intensity of information flow, and subsequently the coordination of the schedule necessary in the construction project, requires general contractors to build stronger ties with several strategic subcontractors and suppliers. Until recently, the fuel of these relations was competition, which often resulted in a conflict. At present, relationships with subcontractors / suppliers have evolved into a partnership in the construction supply chain. As part of a win-win partnership, general contractors, sub-contractors and strategic suppliers pursue the same goals, but also share risk through joint planning and control, striving to create an efficient supply chain with increased information flow. Such coordination allows for improved construction support, introduction of technological innovations and more complex projects at reduced costs. In an ideal final situation, the result for all participants in the supply chain at the construction site should be reduced uncertainty of implementation, providing greater control over costs, time of operation, quality of materials and, consequently, the entire project - and ultimately, final customer satisfaction. Better coordination, cost analysis and overall control through supply chain management on the construction site is a vision that can be achieved.

A better understanding of the company's costs and production capabilities - in particular their ability to manage their resources in projects, including changes in schedule and scope - offers many opportunities for improvement. It provides the conditions for better production control in relations

with subcontractors and suppliers. This approach also allows for improved design of supply chains consisting of those subcontractors and suppliers who provide knowledge and technical facilities - which may result in better work coordination.

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Paweł B. Michalski
Wroclaw University of Economics, Poland
pawel.michalski@ue.wroc.pl